31. Anatomical Notes on the Gruiform Birds *Aramus giganteus* Bonap., and *Rhinochetus kagu*. By P. Chalmers Mitchell, D.Sc., LL.D., F.R.S., F.Z.S., Secretary to the Society.

[Received May 11, 1915: Read May 25, 1915.]

(Text-figures 1–5.)

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In July 1914 the Society purchased from a dealer a bird of unknown source, recognised by Mr. D. Seth-Smith, our Curator of Birds, as being new to our Collection. It turned out to be an example of *Aramus giganteus* Bonap., the Limpkin, Clucking Hen, or Northern Courlan (*Aramus pictus* Bartram of the Brit. Mus. Catalogue, vol. xxiii. p. 238). It is the northern form of the Courlan of S. America, *Aramus scolopaceus*, and is a native of Florida, the Antilles, and Jamaica, somewhat doubtfully accepted as a distinct species because of its larger size, and of the extension of the white stripes, confined in the Courlan to the head and neck, to the back, wing-coverts, and lower parts. The anatomy of *A. scolopaceus* has been studied chiefly by Garrod (P. Z. S. 1876, p. 275) and by myself (P. Z. S. 1901, p. 629). As I could find no record of the anatomical examination of *A. giganteus*, I took the opportunity of dissecting the Society's example when it died after living for a few months in the Gardens; and as I had formerly dissected *A. scolopaceus* along with an example of the Kagu (*Rhinochetus kagu*), I renewed the comparison, by dissecting at the same time another example of the Kagu.

It may be convenient to state at once the general conclusion, that, so far as anatomical characters are concerned, *A. giganteus* resembles *A. scolopaceus* very closely indeed. It would not have surprised me to find such slight differences as I noted between two individuals of the same species. I do not suggest, however, that the two species should be merged. The more experience I gain of avian anatomy, the more I am convinced that systematists are well advised when they rely, at least with regard to the discrimination of species and genera, more on those superficial characters that they can observe in the series of museum collections, than on the uncertain indications afforded by the presence or absence of this or that muscle.

Pterylosis.—An aftershaft is present. There were ten primaries, the most distal being smallest, each covert, as usual, being placed distally to each primary. Dr. Gadow (*Vögel*, in Bronn's Thier-Reich, p. 79) states that there are 11 in *Aramus*, but in some examples of *A. giganteus* and *A. scolopaceus* which I examined with Mr. W. R. Ogilvie-Grant at the British Museum (Natural History) we found only 10. There are also only 10 in *Eurypyga* and *Rhinochetus*. The carpal covert is rather smaller than the carpal remex, and crosses it in the fashion that the secondary coverts cross the secondary quills. A minute plica ties the carpal remex to the most distal secondary quill, and the general disposition bears out the view urged by Degen and myself that the carpal feathers are in series with the secondaries, not with the primaries. The wing is aquintocubital; the diastaxic gap is wide and is occupied by a covert in the normal fashion.

The oil-gland is tufted, and there are twelve rectrices.

The disposition of the feather-tracts, as in *A. scolopaceus*, agrees very closely with Nitzsch's account of *Psophia*.

There were very thick clumps of down on the back, especially on the rump. In the fresh condition these gave off some powder, but detailed examination did not show the presence of true decomposing down. The distribution of powder-downs amongst birds is, as is now well known, far too irregular to be of use in systematic classification.

There are no webs between any of the toes, and the claw of the third digit is unsymmetrical, forming a scoop, slightly notched, but not constituting a definite comb.

Viscera.—Both carotids are present. The trachea is unconvoluted; the rings are highly ossified, and the normal pair of extrinsic muscles and the intrinsic muscles are both present.

The configuration of the alimentary tract is of the generalized type that I have shown (Trans. Linn. Soc., Zool. vol. viii. p. 173, 1901) to underlie the patterns displayed by Charadriiform and Gruiform birds. The duodenum is a long and narrow loop; Meckel's tract is suspended at the circumference of a nearly circular expanse of mesentery; between the duodenum and Meckel's diverticulum there is a single rather wide loop; the diverticulum, which is large and prominent, is placed on the distal limb of the moderately long axial loop, and the distal portion of Meckel's tract is thrown into three or four rather irregular short loops. The cæca are functional, of moderate length, and slightly expanded towards their extremities. The rectum is straight and rather wide. A ganglionated sympathetic nerve chain passes round the mesentery, bending a short way into the more important loops. I have to add to the description I gave of *A. scolopaceus* that there are two bridging veins from the duodenal loop to the distal part of Meckel's tract. The example of *A. scolopaceus* that I examined had been preserved in spirit, and very likely I overlooked the presence of bridging veins. From the evidence afforded by this example of *A. giganteus*, which

I examined before it had been hardened by spirit, I should place the pattern of *Aramus* definitely on the Gruiform stem, rather than at the branching of the Gruiform and Charadriiform stems.

Muscular Anatomy.

Cucullaris.—The cervical portion is much feebler than in *Rhinochetus*, but its posterior edge nearly meets the anterior edge of the rhomboideus externus.

Rhomboideus externus.—A continuous thin sheet of muscle, distally leaving uncovered a good piece of the rhomboideus profundus, and proximally stretching far anterior to it. In *Rhinochetus* the arrangement is similar, but the muscle thins out in the middle region and becomes much thicker in front.

Rhomboideus profundus.—This reaches to the extreme distal end of the scapula and extends forwards almost the whole length of the scapula ; it is much thicker than the superficial muscle.

Latissimus dorsi metapatagialis.—This slender muscle is present, lying just under the skin, superficial to the latissimus dorsi posterior and inserted into the skin underlying the humeral feather-tract. It appears to have similar relations in all the Gruiform birds.

Latissimus dorsi anterior and *l. d. posterior.*—These two muscles are well developed, but do not touch at origin or insertion. The tendinous insertion of the posterior division is just deep of, and in contact with, the anchor of the anconæus humeralis ; its origin is enormous and is partly from the ilium. In *Rhinochetus* the origin from the ilium is smaller, and although the insertion of the posterior division has similar relations with the anconæus anchor, it is just in contact with the proximal edge of the fleshy insertion of the anterior division. In the Crane the two divisions, especially the posterior, are relatively narrower and do not touch at origin or insertion.

Serrati.—The s. superfic. metapatagialis is large, arising only from the ribs without fibres from the scapula, and is inserted to the skin under the dorsal feather-tract. The s. superfic. anterior is a narrow slip arising from one rib and is inserted by a flat band to the scapula between the two divisions of the sub-coraco-scapularis. The s. superfic. posterior is strong, arising from two ribs with their uncinate processes, and passing to the posterior inferior border of the scapula. The s. profundus is in a series of strong separate slips.

Scapuli-humerales anterior et posterior.—The posterior muscle (*teres major*) is large and is pierced by the expansor secundariorum. I found no trace of the anterior muscle, although Fürbringer states its presence in *A. scolopaceus*, and in the example of that bird which I dissected I noted a few fibres representing it. It is absent in *Rhinochetus*.

Deltoides propatagialis.—A rather narrow muscle, not divided into two peaks. It gives rise to the brevis and longus tendons after a very short common course; the brevis tendon is very broad and gives off a distinct distal slip (gamma of Fürbringer), a median patagial fan, and a separate proximal slip (alpha of Fürbringer). There is no recurrent anchor to the longus tendon. The longus tendon is doubled at the elastic part and receives the whole of the biceps patagialis, the tendon of which is very short. The pectoralis patagialis is large and runs to the patagial tendon, where it divides into longus and brevis slips. The condition in *Rhinochetus* is as I have already figured (*loc. cit.* text-fig. 76), except that the alpha and gamma divisions of the brevis were rather better separated.

Deltoides major et minor.—The major is a strong muscle reaching down to the end of the third quarter of the humerus; it is shorter in *Rhinochetus.* The minor, as in other Gruiform birds, is quite separate, and is inserted to the other side of the insertion of the pectoralis minor.

Pectoralis thoracicus.—A very strong muscle with a feeble fibrous anchor to the humerus, and a single elongated tendinous insertion. In *Rhinochetus* the muscle is similar, except that it is narrower, in association with the shallow keel of the sternum.

Supra-coracoideus (*pectoralis minor*), *coraco-brachialis externus*, *coraco-brachialis internus*, and *sub-coraco-scapularis.*—Practically identical in their relations in the two species of *Aramus* and in *Rhinochetus*, except that in *Rhinochetus* the coracoidal origin of the last-named muscle is relatively very much larger.

Anconæus.—The humeralis division, as in the vast majority of birds, is a strong muscle arising from the greater part of the humerus, and is cleft proximally. The scapular head, in addition to the stout anchor to the humerus described in connection with the latissimus dorsi muscles, has the origin from the scapula forked in *Aramus*, simple in *Rhinochetus.* The anconæus caput coracoideum (expansor secundariorum) in *Aramus* presents the arrangement described as "ciconine" by Garrod; that is to say, it arises in the axilla from a triangular ligament which passes into a stout tendon running to be inserted to the proximal secondary quills. I have already stated (P. Z. S. 1901, p. 645) that this arrangement is usual in Gruiform birds, but that I found the muscle feeble, although present, in *Rhinochetus* and *Eurypyga.* In the example of *Rhinochetus* which I used in the dissections I am now describing, I found no trace of the expansor secundariorum in either of the wings. This may serve as another of the many warnings against attaching systematic value to the absence of an anatomical structure, as it may have been lost independently by different descendants of a common ancestor.

Biceps brachii.—In *Aramus* the acrocoracoidal portion of the muscle gives rise to a tendon which, although closely associated with the humeral portion, can be traced separately to the ulna, the humeral portion going to the radius. In *Rhinochetus* the division of the tendon of insertion to the radius and ulna is forked at the extreme distal end. The peculiar accessory head of the biceps, first noted by Beddard (P. Z. S. 1891, p. 14) and confirmed by myself (P. Z. S. 1901, p. 639) from dissection of another example of *Rhinochetus*, was doubtfully represented in the present example, an old and excessively fat bird, by a lump of fat and fibrous tissue.

Ilio-tibialis internus (*sartorius*).—As in other Gruiform birds, rather easily separable from the glutæus maximus.

Ilio-tibialis (*glutæus maximus*).—This large muscle, with rather weak median and very strong post-acetabular portions, had the disposition found in Gruiform birds generally.

Ilio-trochanterici posterior, *anterior*, and *medius*, were all distinct and well developed as in other Gruiform birds, but the small median muscle (*glutæus quartus*) was absent in *A. giganteus* as in *A. scolopaceus*; in the present example of *Rhinochetus* it was just separable.

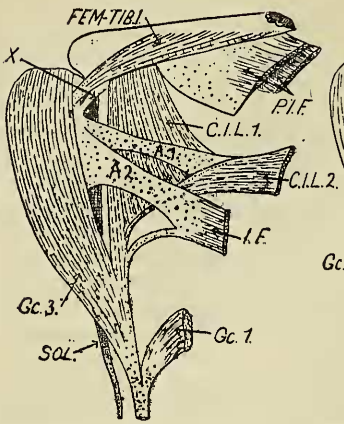
Caud-ilio-femoralis (*femoro-caudal* and *accessory*).—The femoro-caudal was absent in *A. giganteus* as in *A. scolopaceus*, present but small in *Rhinochetus*; the accessory was large, but with an area of tendinous degeneration in *A. giganteus*, precisely as in *A. scolopaceus*, absent in *Rhinochetus*.

Ambiens.—Present in both *A. giganteus* and *Rhinochetus*, its slender tendon, after passing round the knee, receiving a strong anchor from the head of the fibula.

Caud-ilio-flexorius (*semitendinosus* and *accessory semitendinosus*). *Ischio-flexorius* (*semimembranosus*). *Gastrocnemius*, *middle*, or *posterior femoral head.*—For convenience, to explain the interesting relations of this group of muscles, I have repeated here, as text-figures 1–4, the text-figures 81–84 in my paper on Gruiform birds already published in the Proceedings of this Society (P. Z. S. 1901, pp. 650–651). In *A. giganteus*, as in *A. scolopaceus* (text-fig. 2), the semitendinosus (C.I.L. 2) is wide, but not so large as the semimembranosus (I.F.), except towards its insertion, whereas in *Rhinochetus* it is enormous, much larger than the semimembranosus. In *A. giganteus* the accessory semitend. (C.I.L. 2) is a broad triangular muscle, meeting the semitend. in an oblique raphe, exactly as in *A. scolopaceus* (text-fig. 2), and then running down to join the middle head of the gastrocnemius, which it covers; the semimembr., also as represented in that figure, sends a slip to the conjoined semitendinosus and accessory semitend., and passes on to the tibia by a flat ligament (A. 2). There was also a thin flat ligament from the semitend. raphe to the tibia, which I did not find in *A. scolopaceus*, but which I found in *Rallus* (text-fig. 1, A. 1).

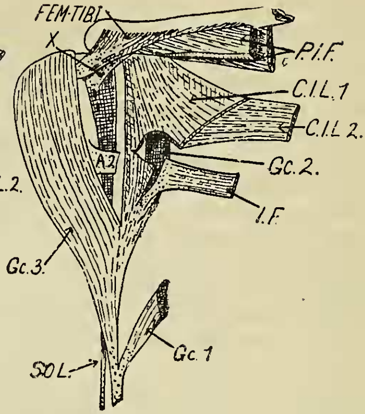
The condition of this group of muscles in the example of *Rhinochetus* that I am now describing, corresponded, except in one important respect, with what I found on a former occasion and described as resembling the condition in *Otis* (text-fig. 3). The semitendinosus, accessory semitend., and semimembranosus unite to form a flat tendon of insertion to the tibia (A. 2) plainly

Text-figure 1.



Knee-muscles of *Rallus longirostris.*

Text-figure 2.



Knee-muscles of *Aramus scolopaceus.*

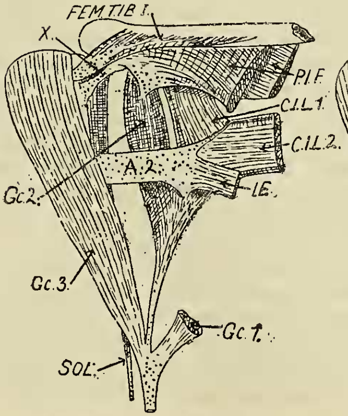
Musculature of knee; right leg, internal view.

FEM.-TIB.-I. Internal separate slip of femoro-tibialis (vastus internus).
X. Ligament from femur to tibia.
P.I.F. Pub-ischio-femorales (adductors).
C.I.L. Caud-ilio-flexorius. *C.I.L.1.* Femoral insertion of caud-ilio-flexorius (accessory semitendinosus). *C.I.L. 2.* Semitendinosus.
I.F. Ischio-flexorius (semimembranosus).
A. 1. Anchor to tibia of *C.I.L.*
A. 2. Anchor to tibia of *I.F.*
Gc. 1. External femoral division of gastrocnemius.
Gc. 2. Internal femoral divison of gastrocnemius.
Gc. 3. Tibial division of gastrocnemius.
SOL. Soleus.

In text-figure 2 the caud-ilio-flexorius has had a piece removed to exhibit the deeper lying *Gc. 2.*

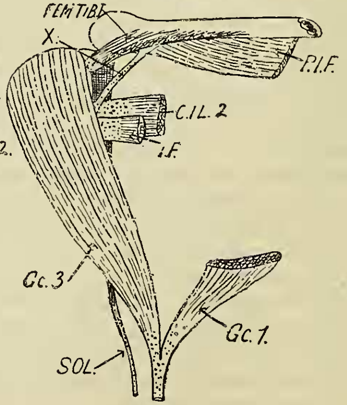
The tendinous areas are dotted.

Text-figure 3.



Knee-muscles of *Otis tarda.*

Text-figure 4.



Knee-muscles of *Heliornis fulica.*

Description and lettering as in text-figures 1 & 2.

identical with the tendon of insertion of the semimembranosus in *Aramus* and *Rallus*. This tendon arises from the semitendinosus raphe, and the muscular bellies pass under it, meet a separate muscle (text-fig. 3, Gc. 2) arising from the femur just proximal to the accessory semitendin., and form a strong tendon that joins the common tendon of the gastrocnemius. A glance at text-figures 1, 2, and 3 will show that this muscle, marked Gc. 2, appears to be present in *Rallus*, *Aramus*, *Otis*, and *Rhinochetus*, but that in the two former it is fused along its edge with the accessory semitendinosus, whilst in the two latter it is free. If, then, we identify the muscle marked Gc. 2 in text-fig. 3 with the middle head of the gastrocnemius, it seems a sufficient statement of the facts to say that the middle head of the gastrocnemius in *Rallus* is either absent, or fused with the accessory semitendinosus. But in both species of *Aramus*, although the accessory semitendinosus is sufficiently broad to pass both for itself and a fused ralline-like middle head of the gastrocnemius, there is, in addition, a distinct middle head (text-fig. 2, Gc. 2) apparently absent in *Rallus*. In *Psophia*, the middle head of the gastrocnemius is double, one portion corresponding with the Gc. 2 in text-fig. 2, another with the Gc. 2 in text-fig. 3. In my paper already cited (P. Z. S. 1901) I stated that the external head of the gastrocnemius in *Otis* was trifid, one of the three origins passing under the biceps. I do not doubt but that the latter is morphologically identical with the slip marked Gc. 2 in text-fig. 2. In the example of *Rhinochetus* that I am now describing, I found precisely the same condition; not only is the Gc. 2, represented in text-fig. 3, present, but there is also a separate middle head corresponding with the Gc. 2 of text-fig. 2. Dr. Beddard (P. Z. S. 1891, p. 16) has published a description and an incompletely lettered figure of the gastrocnemius and its relations in *Rhinochetus*. Although his description is difficult to follow, as it omits reference to the tibial head of the gastrocnemius which, so far as I know, occurs in all birds, and refers to a head "formed by a broad flat tendon to the head of the fibula," a disposition which is at least abnormal in Avian anatomy, I infer that the arrangement of the gastrocnemius in the example of *Rhinochetus* that he dissected was identical with that which I describe here.

For some time I have been collecting notes on the various fashions in which the middle head of the gastrocnemius and the accessory semitendinosus are disposed in birds, but I do not wish to offer these results for publication until I can present a fairly complete picture of their distribution in the Avian system. Dr. Gadow (*Vögel*, in Bronn's Thier-Reich, p. 184) distinguishes three conditions of this complex: (i.) when the accessory semitendinosus cannot be separated from the middle head of the gastrocnemius; (ii.) when both muscles are present but quite distinct except in so far as they may be connected by secondary tendons; (iii.) when the accessory semitendinosus is absent but the middle head of the gastrocnemius present. This grouping will not contain all the facts; there is a condition, as in *Rhinochetus* and *Psophia*, which corresponds with Gadow's second group, except that there is, in addition, a second distinct middle gastrocnemius.

Gastrocnemius, *external femoral head*, and *internal tibial head*. *Ilio-fibularis* (*biceps*, with sling and anchor). *Soleus*.—All these presented no peculiarity, and were similar in the two species of *Aramus* and in *Rhinochetus*.

Pub-ischio-femorales (*adductors*).—In all three birds both were present, without trace of tendinous degeneration, and, as in most Gruiform birds, the internal muscle was much stronger and wider than the external muscle.

Ischio-femoralis (*obdurator externus*), *obdurator* (*obdurator internus*); *accessorii obduratoris*.—With regard to these muscles, I have to note only that the obdurator externus was notably small in *A. giganteus*, and that the area of insertion, to the shape of which Garrod attached importance, was markedly triangular in that bird, as in *A. scolopaceus* and in Rails and Cranes. It is much more oval in *Rhinochetus*.

Peroneus superficialis and *peroneus profundus*.—In both species of *Aramus* and in *Rhinochetus* the superficial muscle is the more important, with a broad superficial origin, extensive origin from the fascia of the adjacent muscles and, in *Aramus*, almost no deep origin, but a certain amount of it in *Rhinochetus*. The anchor to the sustentaculum of the flexor tendons is broad in all three and shows traces of being broken into separate slips.. The tendinous slip to the flexor of the third digit is well developed in all three birds. The deep muscle is very strong in *Rhinochetus*, arising from a large part of the fibula, beginning at the insertion of the biceps tendon, and from the adjacent surface of the tibia. It passes in the normal fashion into a flattened tendon running in a groove under the slip to digit III of the superficial muscle. In *A. scolopaceus* I did not find it, but in *A. giganteus* it was represented by a very minute muscular head arising high up from the fibula opposite the biceps insertion, and passing at once into a most slender ossified tendon, so closely adherent to the fibula that, unless it were specially searched for, it might easily be missed. It has the usual insertion by a very thin flattened tendon in a groove under the slip to III. The tendons of both peroneals were ossified in *Aramus*, as in many other Gruiform and Limicoline birds, but in *Rhinochetus* there was no trace of ossification. I have shown, in a former communication to the Society ("The Peroneal Muscles in Birds," P. Z. S. 1913), that in Gruiform birds there is a tendency for the deep peroneal to become reduced or to disappear, so that it would not be remarkable to find it present in *A. giganteus* and absent in *A. scolopaceus*, even if these forms were not specifically distinct.

Tibialis anticus; *Extensor digitorum communis*; *Flexores perforantes et perforati* of digits II and III.—These muscles are all present in both species of *Aramus* and in *Rhinochetus* and have the disposition that is normal in birds generally. The most notable point of difference is that in *Aramus* the tendons are all ossified, above and below the ankle, and are unossified in *Rhinochetus*. The flexor tendon of digit III is connected with the perforated flexor tendon of the same digit by a strong slip.

Flexores perforati, of digits II, III, IV.—In all three birds, as in Gruiform birds generally, there are three heads for this group of muscles, and fibres from each of the three tendons can be traced to each of the three heads. The ambiens head is the tendon of the ambiens muscle, which passes under the biceps ligament, that is to say, between it and the fibula. The fibular or external head arises by a tendon from the fibula, proximal to the insertion of the biceps and passing superficially to the biceps tendon. The deep or femoral head is fleshy from between the condyles of the femur.

Flexor longis hallucis.—In all three birds this arises by a single head from between the condyles of the femur.

Flexor profundus.—Arises from the shaft of the tibia close under the fibula. In *Aramus* the tendons of the deep flexors are nearly equal in size ; in *Rhinochetus* the tendon of the longus hallucis is relatively smaller. In *A. giganteus* the relations between the two deep tendons are much as I represented in *A. scolopaceus* (P. Z. S. 1901, p. 654), except that the vinculum to the other deep flexor is spread over the branches to the digits rather more, as in the figure of *Eurypyga* given on the same page. The present example of *Rhinochetus* was exactly similar in this respect to the figure I have given, also on the same page.

The muscular anatomy affords small ground for separating *A. giganteus* from *A. scolopaceus*. The most notable differences relate to muscles that are degenerate in the group, and that might even vary individually—such as the presence of a teres minor in *A. scolopaceus* which is absent in *A. giganteus*, and the presence of a peroneus profundus in the latter species and its absence in the former.

The muscular arrangements in which the two species of *Aramus* agree and differ from Cranes are more numerous, and are in conformity with the separation of a sub-family Araminæ.

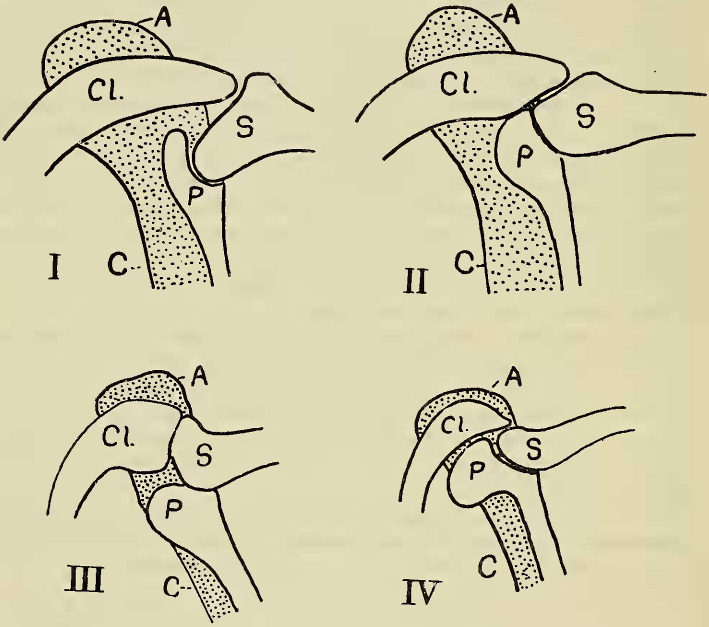
Osteology.

I have noted only a few osteological points, the systematic value of which I do not propose to discuss.

Like that of *A. scolopaceus*, the skull of *A. giganteus* is strongly schizorhinal ; the lacrimals are not fused with the skull as occurs in *Rhinochetus* and Limicoline birds. The palate is widely schizognathous with a long pointed vomer, and the pterygoids are short, and expanded anteriorly as in *Grus*. Also, as in *Grus*, there is a pair of occipital foramina, and strong descending exoccipital processes, both absent in *Rhinochetus*. The skulls of both species of *Aramus* are exceedingly like those of true Cranes, the likeness extending not only to the larger characters that have been employed in classification, but to the minute configuration of the bones.

Sternum.—In Gadow's valuable synoptic table (*Vögel*, in Bronn's Thier-Reich, p. 79), he states that the external spine is very large in Grues (in which he includes *Aramus*) and very small in *Rhinochetus*, and that the internal spine is absent in Grues and in *Rhinochetus*. With regard to the internal spine, I confirm his statement for Cranes, *Rhinochetus*, and both species of *Aramus*. The external spine is certainly small in *Rhinochetus*, but it was also small in both species of *Aramus*. In the examples of *Grus* that I have examined (*G. australasiana* and *G. carunculata*) the external spine was very large and hollowed for a coil of the windpipe. In an example of *Balearica*, on the other hand, it was as minute as in *Aramus* and *Rhinochetus*. The sex of the skeleton had not been noted, but it appears probable that the huge external spine of Cranes is developed in connection with the

Text-figure 5.



Shoulder-girdle articulations in Gruiform Birds. I. *Balearica*. II. *Grus* (*australasiana* & *carunculata*) III. *Aramus giganteus*. IV. *Rhinochetus kagu*.

A. Acrocoracoidal process of coracoid. *C*. Coracoid. *Cl*. Clavicle. *P*. Procoracoidal process of coracoid. *S*. Scapula.

windpipe, and is not to be regarded as a character of systematic value.

Shoulder-girdle articulation.—In text-fig. 5 I give drawings of the relations of the coracoid, scapula, and clavicle, to which Fürbringer has paid so much attention in his great monograph on Birds. Fürbringer has figured the same structures in the case of *Grus*, *Psophia*, *Aramus*, *Eurypyga*, *Dicholophus*, and *Otis* (Morph. u. System. der Vögel, 1888, pl. ii., figs. 40–45). Comparison of his figures with those that I give here, will show that, within the limits of Gruiform birds, the characters vary considerably and are difficult to value for systematic purposes. *Balearica* agrees very closely with the figure Fürbringer gives for *Grus*, except that the procoracoidal process is not quite so large. My figure of *Grus*, which applies equally to *G.. australasiana* and to *G. carunculata*, shows much closer articulation of the clavicle and scapula than was figured by Fürbringer, as well as a smaller procoracoidal process.

Aramus giganteus differs from the figure given by Fürbringer, possibly for *A. scolopaceus*, in that the articular end of the clavicle forms a broad flattened plate articulating with the scapula.

Rhinochetus has a large procoracoid, and very slight articulation of clavicle and scapula. According to Fürbringer, *Psophia* shows the most complete articulation of scapula, clavicle, and procoracoid.

Systematic Position of *Aramus*.—I have already shown (P. Z. S. 1901, pp. 629–655) that *A. scolopaceus* fitted naturally with Gruiform birds, and the examination of *A. giganteus* confirms this in every respect.